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(54) **Pig**

(57) A pig includes a self-propelled vehicle having an endless crawler extended over an idle wheel and a drive wheel through the intermediary of guide rollers on each side thereof and the motion of a driving motor mounted on the vehicle is transmitted to the endless crawler thereby freely moving the vehicle within a pipe. The apparatus includes an operating unit for automatic grinding-cleaning or coating purposes which is mounted on the forward end of the vehicle, a radioactive substance mounted on the vehicle for detecting the position of movement of the vehicle, an inside television camera mounted on the vehicle for monitoring the internal conditions of the pipe and a cleaning unit mounted on the rear end of the vehicle.

FIG. 4

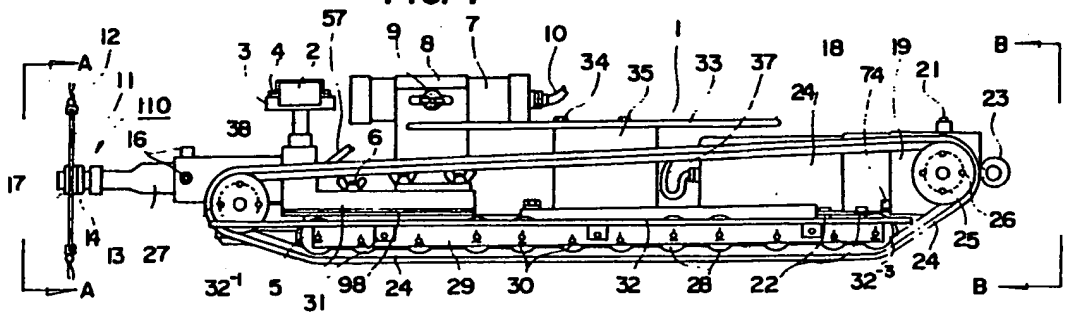


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FIG. 12a

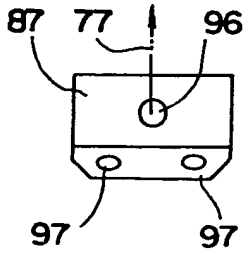



FIG. 12b


FIG. 15

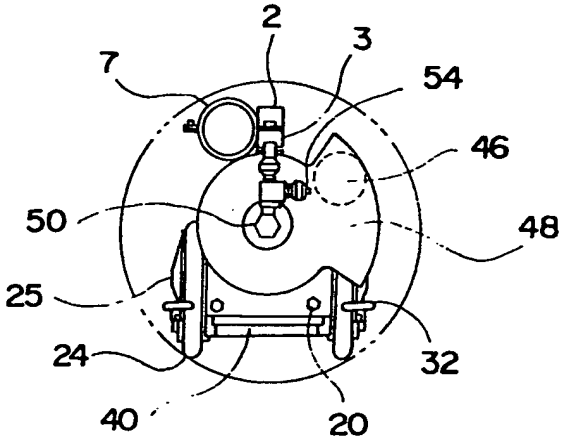
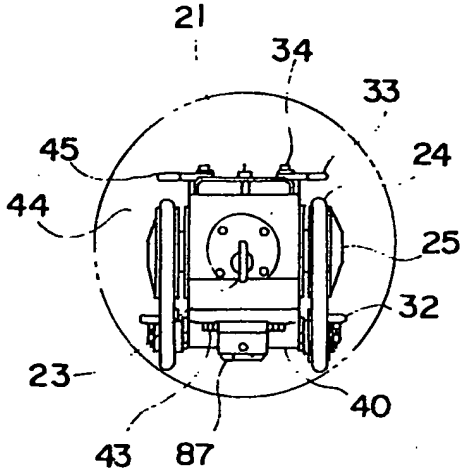



FIG. 16



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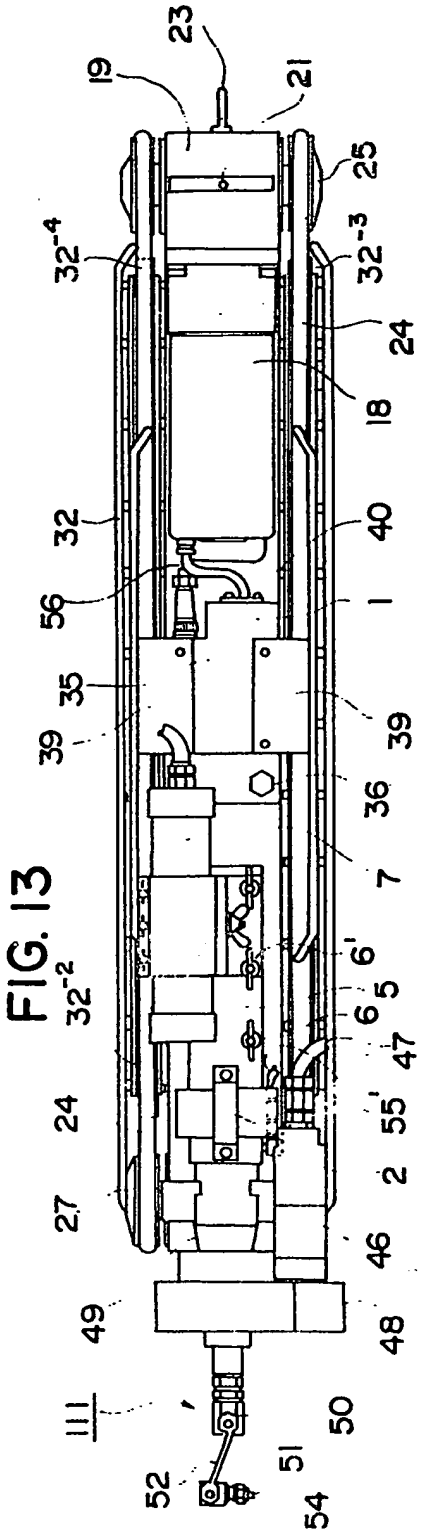


FIG. 13

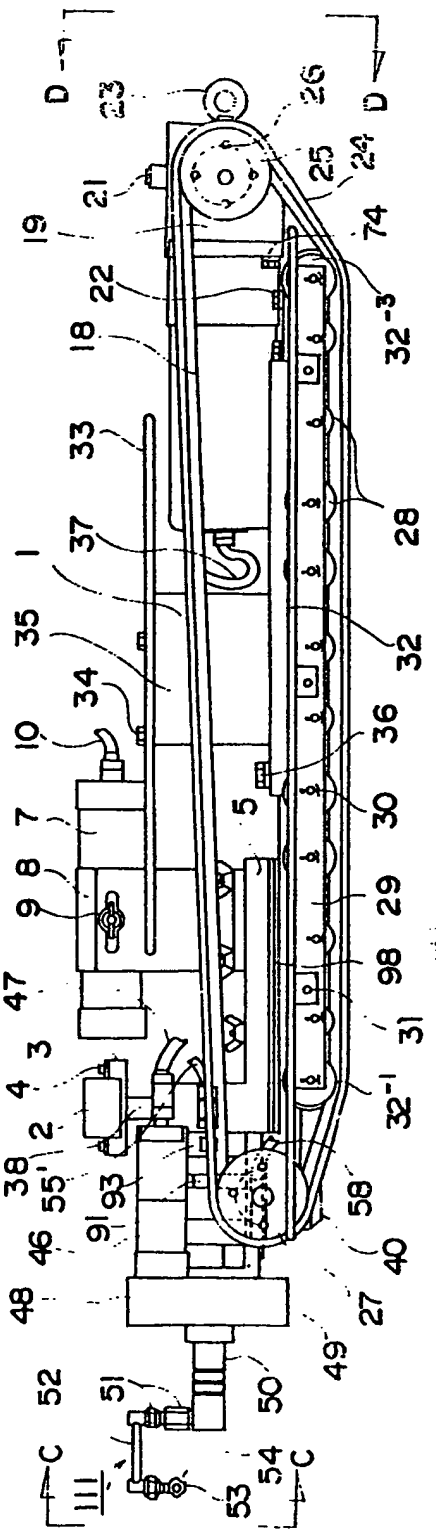


FIG. 14

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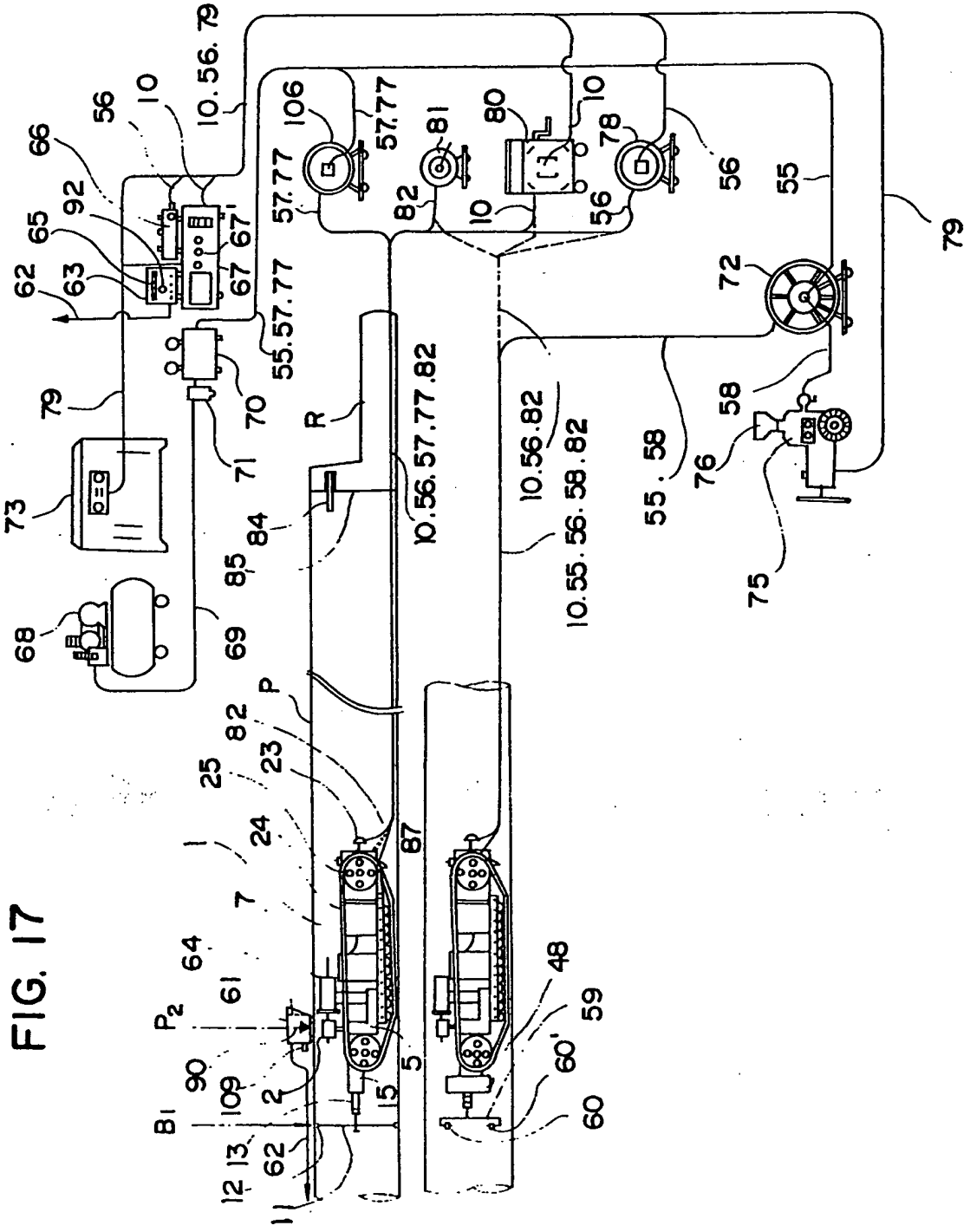


FIG. 17

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FIG. 18a

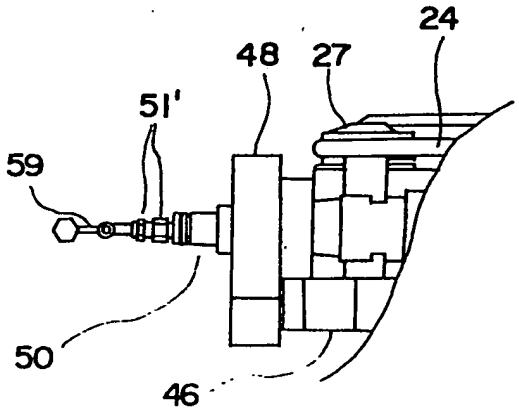


FIG. 18b

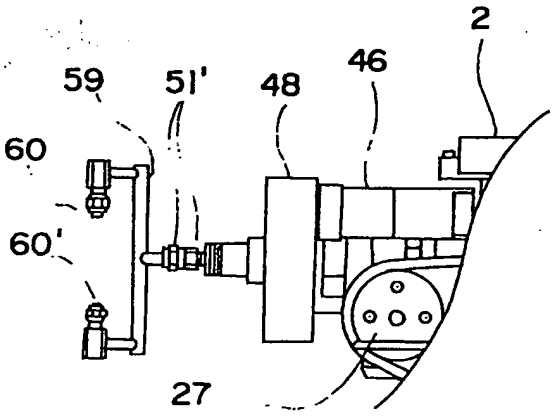

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FIG. 19a

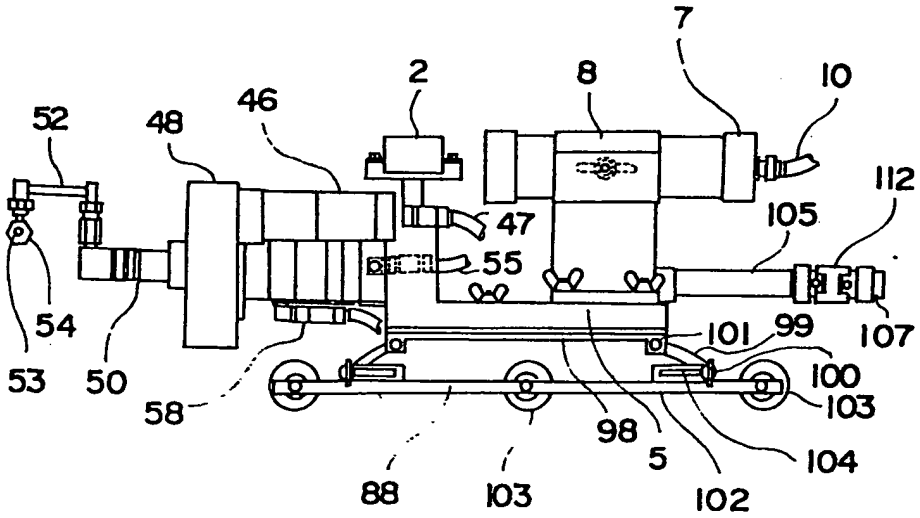
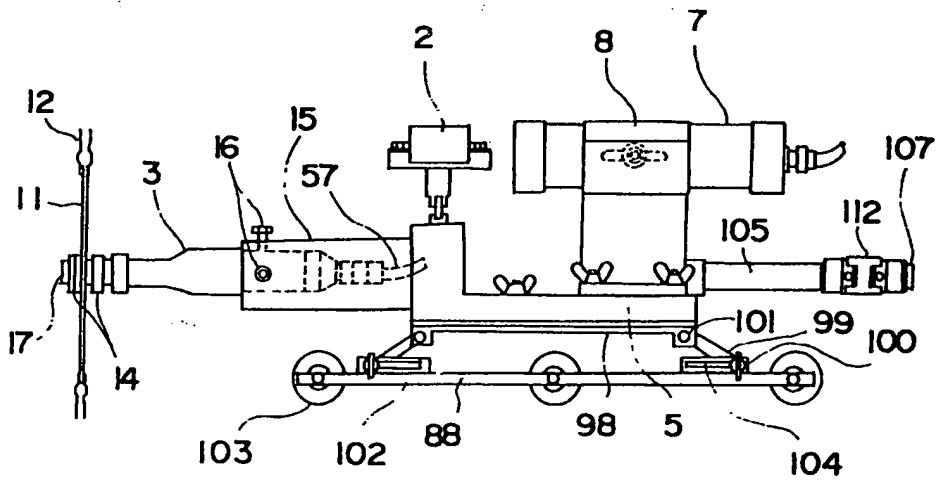



FIG. 19b



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PRIOR ART

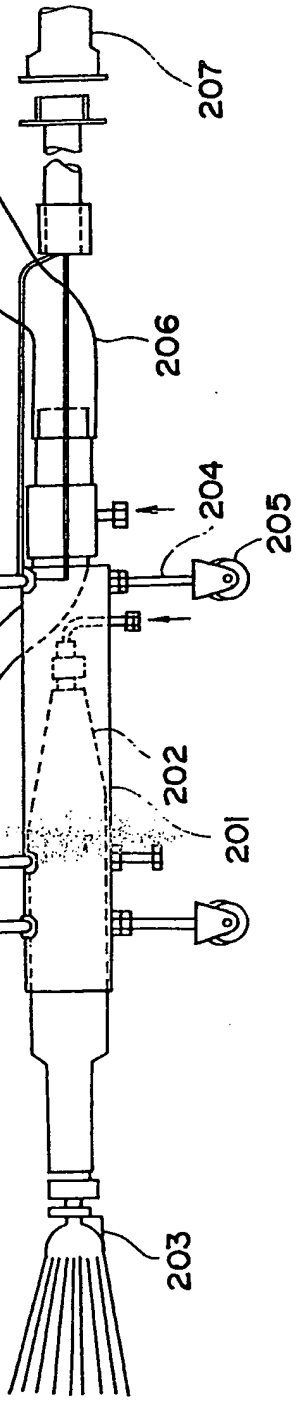


FIG. 1

PRIOR ART

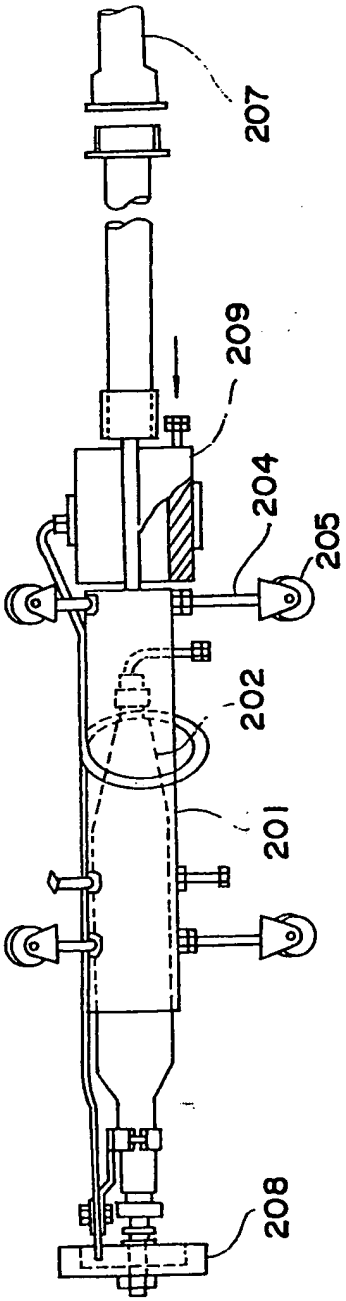


FIG. 2

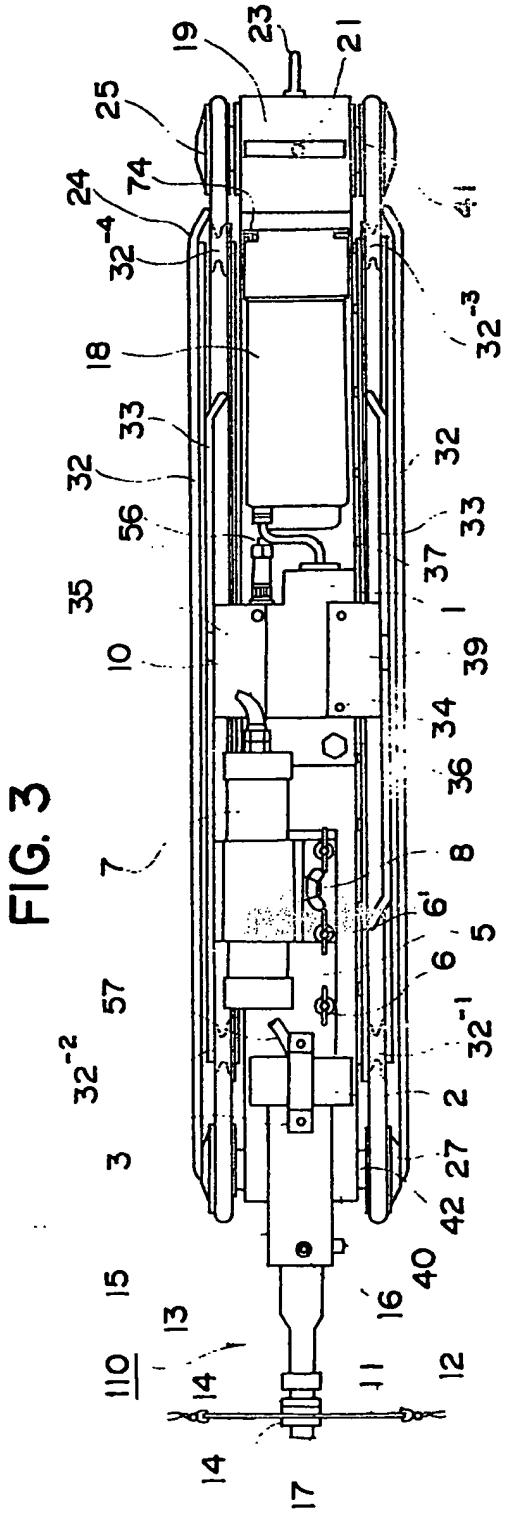

FIG. 3

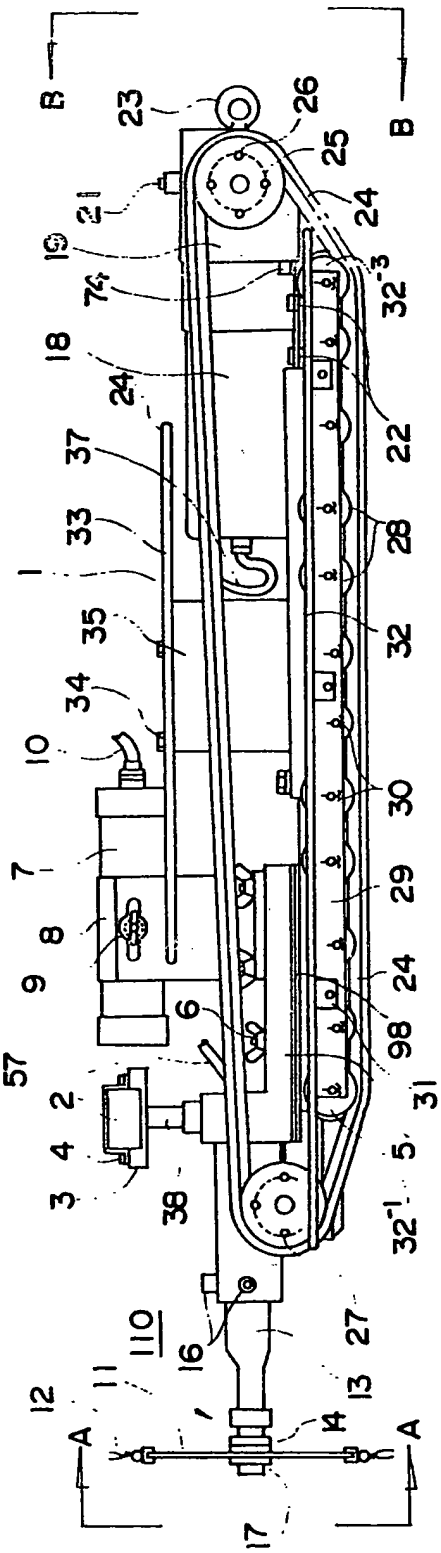

FIG. 4

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FIG. 5

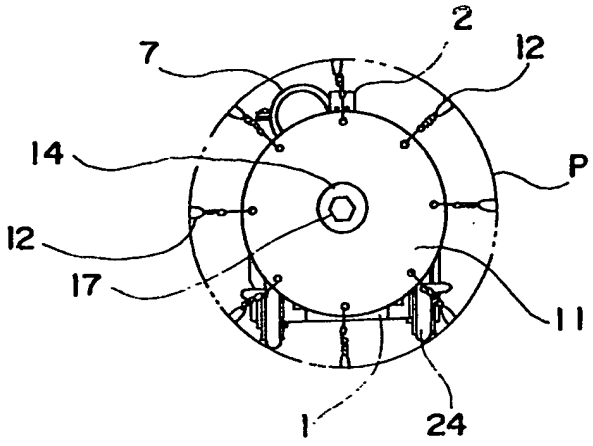
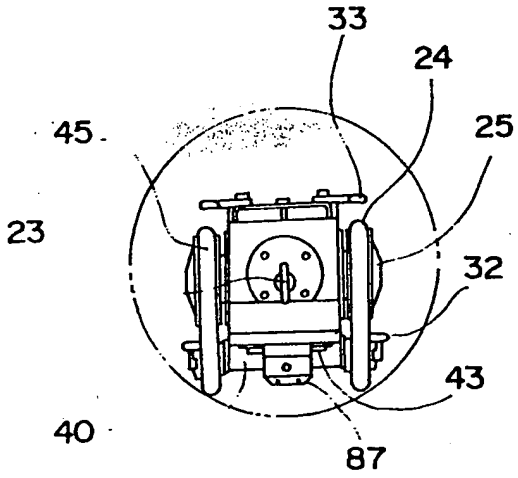



FIG. 6



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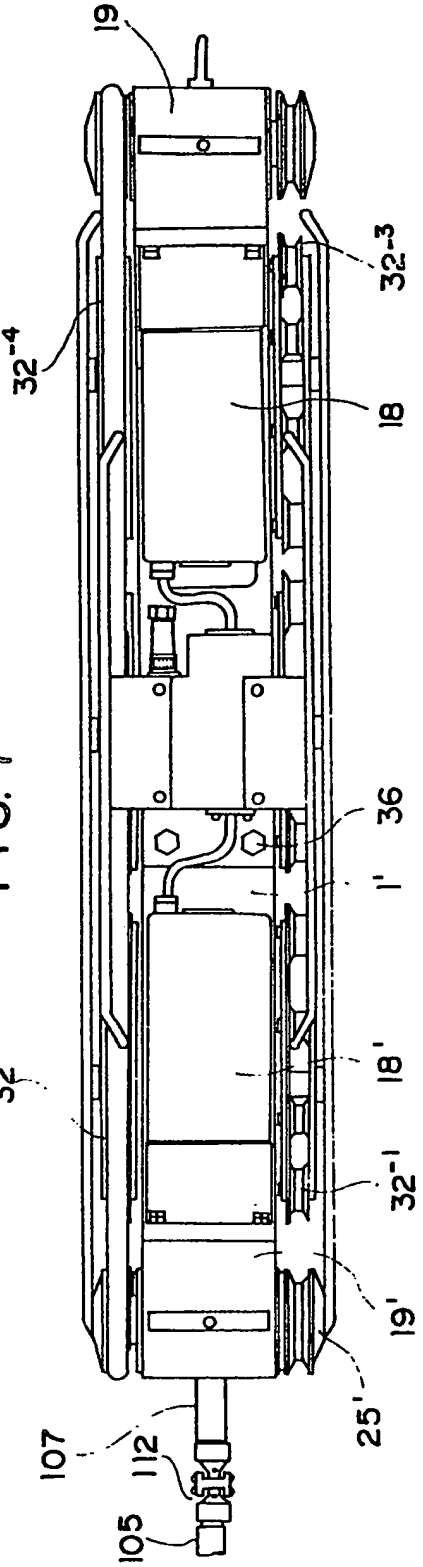


FIG. 7

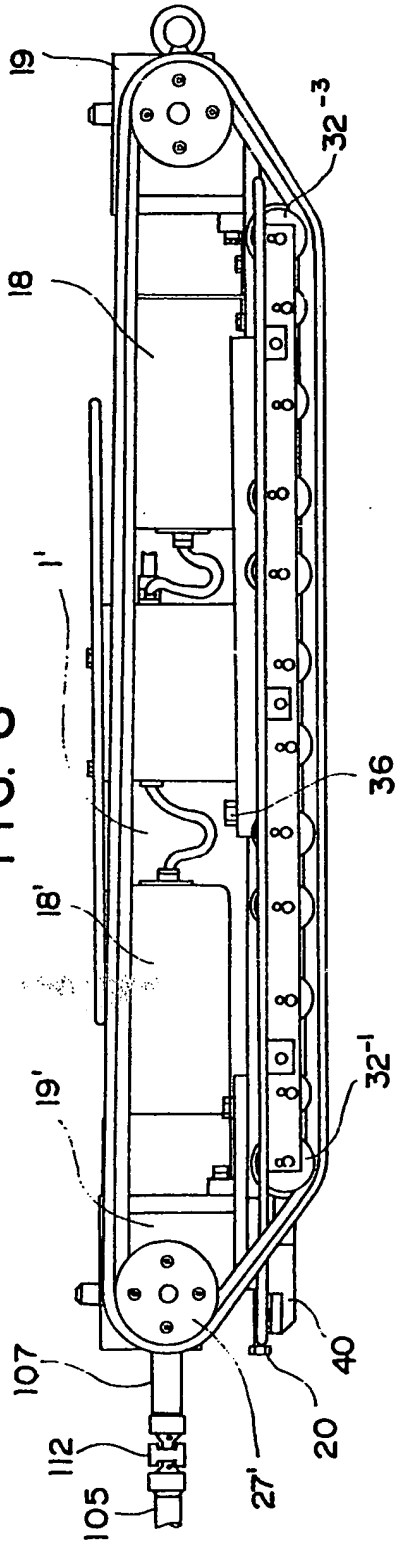


FIG. 8

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FIG. 9a

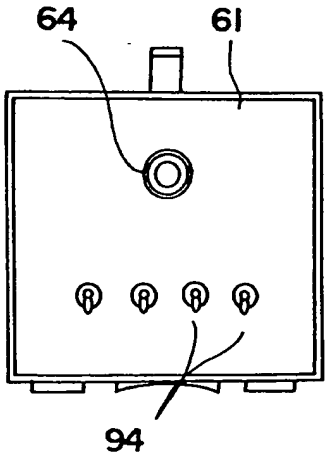



FIG. 9b

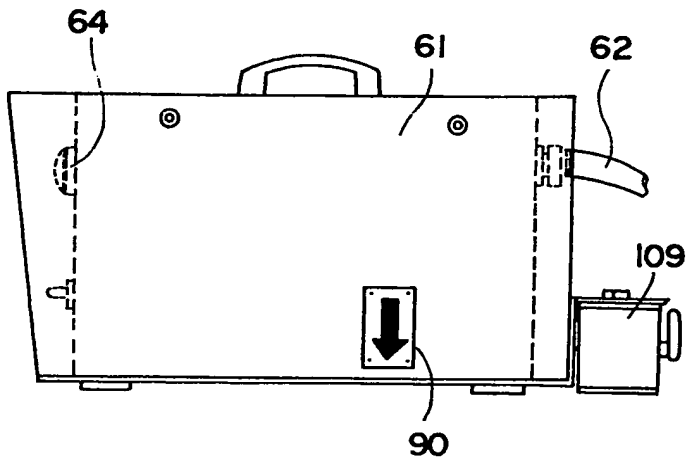



FIG. 10

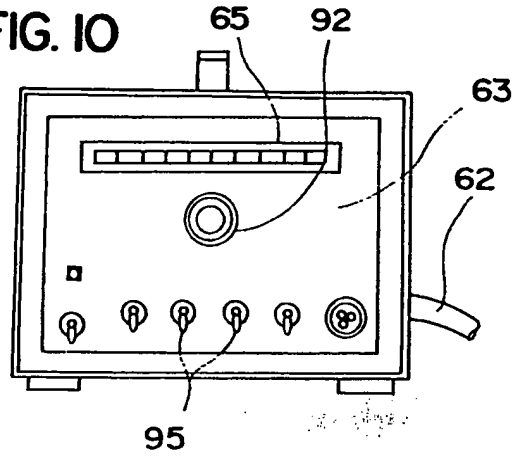
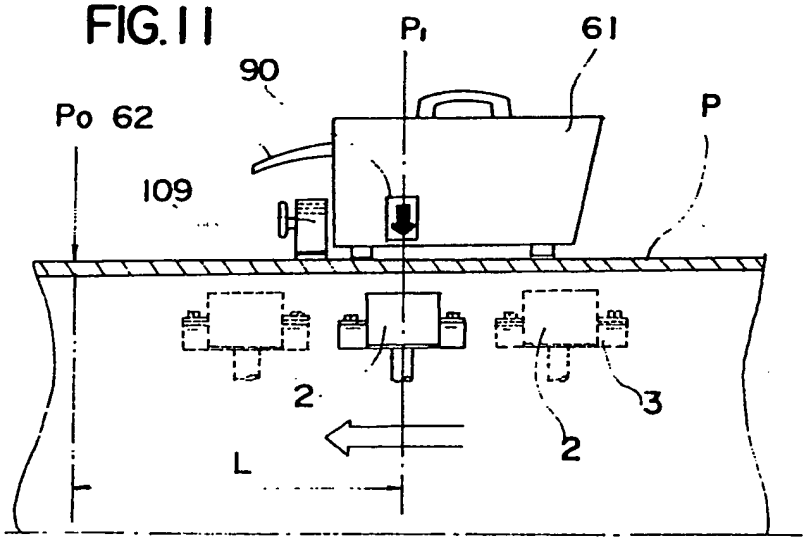



FIG. 11



SPECIFICATION

**Inner-surface coating apparatus for pipes**

The present invention relates to an inner-surface coating apparatus for pipes.

In the installation of wafer main, drain pipe, sea-water pipe or the like, it has been the usual practice so that individual unit pipes having the inner surfaces preliminarily coated at a factory are welded together on the site. After the welding, if a corrosion-resistant paint is to be applied to the inner surface of the welded pipe at the joints and the adjacent portions, the remaining welding slag, rust, etc., must be cleaned by grinding and removed. In the case of welded pipes of less than 600mm in diameter, however, it has been impossible to effect the above-mentioned corrosion-resistant coating due to the difficulty for the operator to get into the pipe and perform the required grinding-cleaning and removing operation.

Coating apparatus heretofore known for applying a corrosion-resistant coating to the inner surface of such small-diameter pipes include for example a coating apparatus disclosed in Japanese Laid-Open Utility Model Registration No. 54–93066 (published on July 2, 1979) which includes an air motor-driven operating unit which is forced into a pipe by a transfer pipe to perform both coating and grinding (rust removing) operations.

However, the known coating apparatus of this type is disadvantageous in that the detection of an inside coating position of a pipe is effected by determining the position on the basis of the distance of insertion of the transfer pipe into the pipe and therefore the detection accuracy of coating position is deteriorated. Also, the known coating apparatus is disadvantageous in that since the transfer pipe must be extended in the case of a long pipe, there is the danger of the extended transfer pipe being deflected thus not only further deteriorating the position detecting accuracy but also considerably limiting the distance of insertion of the transfer pipe into the pipe and making impossible the coating of long pipes and so on.

With a view to overcoming the foregoing deficiencies in the prior art, it is the primary object of the invention to provide an improved inner-surface coating apparatus for pipes which is capable of accurately detecting the desired coating position on the inner surface of a pipe, capable of coating the inside of long pipes and capable of rapidly effecting the coating of a pipe by remote controlling externally of the pipe.

In accordance with the present invention there is thus provided an inner-surface coating apparatus for pipes in which an endless crawler belt is extended over an idle wheel and a drive wheel through the intermediary of guide rollers on each side of a self-propelled vehicle and the motion of a driving motor mounted on the self propelled vehicle is transmitted to the endless crawler belts thereby moving the self-propelled vehicle as desired through remote control. The apparatus includes an operating unit mounted at the forward end of the vehicle for automatic grinding-cleaning or coating purposes and a cleaning unit mounted at the rear end of the vehicle. The coating apparatus further includes a radioactive substance mounted on the vehicle so as to detect the position of the vehicle within the pipe from the outside and it is possible to detect the radioactive rays, such as gamma rays radiated from the radioactive substance from the outside of the pipe.

In accordance with the invention, by virtue of the fact that the endless crawler belt is extended over the idle wheel and the drive wheel through the guide rollers on each side of the self-propelled vehicle and the motion of the driving motor mounted on the vehicle is transmitted to the endless crawler belts thereby moving the vehicle freely as mentioned previously, there are the effects that the vehicle is moved deep into a long pipe without using any long transfer pipe to effect the coating inside the long pipe and that the detection of the desired coating position is effected accurately due to the provision of the radioactive substance. Also, the invention has the effects that the inner conditions of a pipe are detected accurately through the provision of a television camera and that the cleaning operation inside the pipe is made possible by the provision of the cleaning unit. Further, the invention has the effect both the grinding-cleaning and coating operations inside a pipe are possible through the provision of the automatic grinding-cleaning unit and the coating unit.

The above and other objects as well as advantageous features of the invention will become more clear from the following description taken in conjunction with the drawings, in which:–

*Figures 1 and 2* are side views showing the construction of a prior art coating apparatus.

*Figures 3 to 19* show embodiments of the present invention, in which Fig. 3 is a plan view of an inner-surface coating apparatus for pipes which includes a grinding-cleaner mounted on a single motored self-propelled vehicle, Fig. 4 is a side view of the inside-surface coating apparatus of Fig. 3, Fig. 5 is a view looked in the direction of arrows A–A of Fig. 4, Fig. 6 is a view looked in the direction of arrows B–B, Fig. 7 is a plan view of a self-propelled vehicle equipped with two motors, Fig. 8 is a side view of the self-propelled vehicle shown in Fig. 7, Figs. 9a and 9b are respectively a front view and side view of a detector, Fig. 10 is a front view of a level indicator, Fig. 11 is a schematic view showing

the manner in which the detection is effected by the detector stationarily positioned on the pipe, Figs. 12a and 12b are respectively a front view and side view of a cleaning unit, Fig. 13 is a plan view of an inner-surface coating apparatus for pipes which includes a coater mounted on a single motored self-propelled vehicle, Fig. 14 is a side view of the inner-surface coating apparatus shown in Fig. 13, Fig. 15 is a view looked in the direction of arrows C–C of Fig. 14, Fig. 16 is a view looked in the direction of arrows D–D of Fig. 14, Fig. 17 is a schematic diagram showing the manners in which the inner-surface coating apparatus is used, Figs. 18a and 18b are respectively a plan view and side view showing schematically the construction of a T-type extension nozzle portion, Fig. 19a is a side view of a grinding-cleaning unit used by connecting to a two motored tractor, and Fig. 19b is a side view of the coater truck shown in Fig. 19a.

Firstly, the prior art apparatus disclosed in the previously mentioned Japanese Laid-Open Utility Model Registration No. 54–93066 will be described with reference Figs. 1 and 2.

Fig. 1 shows a case in which the prior art coating apparatus is utilized for performing grinding and dust collecting operations and Fig. 2 shows another case in which the coating apparatus is used for performing a coating operation.

In Fig. 1, numeral 201 designates a coating apparatus body. An air motor 202 is incorporated in the body 1 and a wire-brush 203 is detachably attached to the forward end of the air motor 202. Six supporting arms 204 are detachably attached to the periphery of the body 201 and a roller 205 is provided at the forward end of each supporting arm 204. A dust collector 206 is connected to the rear end of the body 201. A transfer pipe 207 is adapted for connection to the rear end of the dust collector 206. It is to be noted that the transfer pipe 207 can be extended for introducing the body 201 into a pipe in case of need.

Fig. 2 shows the case where a coating wheel 208 is attached to the forward end of the body 201 in place of the wire brush 203 shown in Fig. 1 and a coater 209 is attached to the rear end of the body 1 in place of the dust collector 206. In Fig. 2, the same reference numerals as used in Fig. 1 designate the identical component parts.

The above-described prior art coating apparatus performs its operations in the following order of *a* and *b*.

a: Grinding and dust collecting operations

The grinding operation is performed by inserting the prior art coating apparatus of Fig. 1 into a pipe and then turning the wire brush 203 and the dust collecting operation is performed by operating the dust collector 206.

In performing the grinding and dust collecting operations, if the prior art coating apparatus is to be inserted into a long pipe, the operations are performed by suitably extending the transfer pipe 207.

b: Coating operation

The coating operation is effected after the grinding and dust collecting operations. The coating operation is effected by inserting the prior art coating apparatus of Fig. 2 into the pipe and then spraying the paint supplied from the coater 209 by the coating wheel 208. It is to be noted that in performing the coating operation, if the prior art coating apparatus is to be inserted in a long pipe, the transfer pipe 207 is extended as in the case of the grinding and dust collecting operations.

Figs. 3 to 19 show embodiments of the present invention and numeral 1 designates a self-propelled vehicle. The self-propelled vehicle 1 is adapted to move an automatic grinding-cleaner 110 and an inside television camera 7 to a distant grinding-cleaning position and it includes a grinding-cleaning air hose 57, a cleaning air hose 77, an electric conductor cable 56, an auxiliary wire 82 and a control cable 10 for supplying power source air and electric power. An electric motor 18 forming a self-propelling power source is mounted on the rear part of a vehicle base 40. The electric motor 18 is supplied with electric power from an externally installed generator 73 through the conductor cable 56, a connector protecting and weight adjusting support 35 and a lead cable 37.

The rotary motion produced by the electric motor 18 is transmitted to a transmission gear 19 and then to a drive wheel 25 mounted on each end of a shaft 41 by connecting fixed screws 26 and the rotary motion is converted to a longitudinal rotary motion relative to the vehicle base 40.

This longitudinal rotary motion is transmitted to endless crawler belts 24 each including a rubber belt or the like extended over three rotating wheels, i.e., an idle wheel 27 attached to the forward end of the vehicle base 40 by a shaft 42, the drive wheel 25 and free-rotation guide rollers 28 which determine the direction of rotation and the height of the vehicle body by a saddle 29 made integral with the vehicle base 40 with three-point support members 31 and locking pins 30. Thus, when the electric motor 18 is rotated, the vehicle 1 is moved forward or backward inside a pipe P by the frictional resistance at the contact surfaces between the pipe P and the endless crawler belts 24. The control of the forward and backward movements is effected easily and accurately by means of the start button and the speed adjusting sliding knob of a control panel 66 through the conductor cable 56 by remote control.

Numerals 32 and 33 designate respectively top and bottom protective skid bars screwed to the vehicle 1 so as to prevent damages to the vehicle 1 during its transportation, 39 top protecting skid holding plates, 34 holding plate screws, and 31 bottom protective skid support members concurrently serving as the support members for holding the saddles 29 in place.

On the other hand, assuming the occurrence of a situation in which the vehicle 1 turns sideways within the pipe P by any chance, each of the top and bottom protective skid bars 33 and 32 has its ends bent inwardly and each of the drive wheels 25 and the idle wheels 27 has its outer end formed into a conical shape so as to facilitate its sliding. Thus, if such an accident occurs, the vehicle 1 can be moved out of the pipe easily by pulling the auxiliary wire 82.

Also, the vehicle 1 has the following advantages. As will be presumed from Fig. 6, the vehicle base 40 accounting for the major weight of the vehicle 1 is arranged in the vehicle lower part and this ensures a low gravitational center arrangement for the vehicle even after its insertion into the pipe 1. When the vehicle 1 makes a rectilinear motion within the pipe P, it is moved by the frictional resistance at the contact surfaces between the inner surface of the pipe P and the narrow endless crawler belts 24 over the width of guide rollers ($32^{-1}$–$32^{-3}$, $32^{-2}$–$32^{-4}$). However, if the vehicle 1 is moved within a curved pipe, assuming that the inner surface of the curved pipe is curved counterclockwise with respect to the direction of forward movement, the greater part of the vehicle weight is loaded on and around the guide rollers $32^{-2}$ and $32^{-3}$.

By virtue of the interaction between this phenomemon and the fact that the vehicle has a low gravitational centre with respect to the center line of the pipe, when the vehicle 1 is moved forward, the portion including the forward guide roller $32^{-2}$ is moved forward without excessively rising on the pipe inner surface but suitably sliding down the inner wall. Thus, in the case of a curved pipe that permits the movement of the vehicle 1 thetein, the vehicle 1 is moved smoothly without the danger of turning sideways.

Another advantage is that the vehicle can be used in cases where the tractive force of the vehicle must increased and the distance of travel must also be increased. The electric motor 18 and the transmission gear 19 are joined together by connecting screws 74 and are fixed to the vehicle base 40 with base screws 22 thus making it possible to easily detach them by loosening the base screws 22. This arrangement is also applicable to the vehicle front part.

Since the vehicle base 40 and the base of the transmission gear 19 are fastened together by means of the intermeshing base screws 22 and this arrangement is also applicable to the vehicle front part, if the front part grinding cleaner and coater which will be described later are removed and the identical electric motor 18′ and transmission gear 19′ as their counterparts mounted in the rear part are mounted as shown in Figs. 7 and 8, the idle wheels 27 are converted to drive wheels 25′ and the vehicle 1 is then movable with the increased driving power. Namely, this four-wheel drive wheel system increases the tractive force further thus making it possible to introduce the cable deeper into the pipe and increase the distance of vehicle travel.

Where the four-wheel drive wheel system is used, the grinding cleaner and the coater are connected to the vehicle as will be described later.

The other members sharing the functions of the self-propelled vehicle body include adjusting screws 20 shown in Fig. 8. The screws 20 are used for the purpose of adjusting the tension of the endless crawler belts, replacing the endless crawler belts and mounting and demounting the electric motor and the transmission gear. Numeral 36 designates fastening screws for the front and rear vehicle bases 40.

The essential component elements for grinding-cleaning and coating purposes will now be described.

Numerals 2 designates a low-level radioactive substance which produces radioactive rays such as gamma rays and serves as a mark that always informs the position of the vehicle during its movement within a pipe and it is mounted faceup on the top of a supporting screw 38 having an adjustable height by means of a metal support 3 and metal support screws 4 in the vehicle front part. The supporting screw 38 is screwed to a fixed base 5 capable of adjusting the height of the radioactive substance 2 by its plate thickness and the fixed base 5 is firmly fixed to the vehicle base 40 by locking support screws 6.

Detecting means for detecting the radioactive rays from the radioactive substance 2 from outside the pipe P includes three components as shown in Figs. 9a, 9b, 10 and 11. They include a detector 61 incorporating a G–M tube for detecting the radioactive rays from the radioactive substance 2 and their magnitude, an indicator 63 installed at a pipe end shop and a joint cable 62 for the transmission of electric signals between the detector 61 and the indicator 63.

Using a mark 90 (indicating the position of the G–M tube) of the detector 61 as a guide, the detector 61 is stationarily positioned on the pipe P just above a position $P_1$ apart by a predetermined distance L from a position $P_0$ of the pipe portion to be cleaned by grinding and coated by a magnet 109 and the joint cable 62 is connected to the detector 61 and

the indicator 63. As the radioactive substance 2 mounted on the vehicle 1 is brought nearer to the previously mentioned pipe position $P_1$, the G–M tube of the detector 61 starts generating an output and a signal lamp 64 is flashed on and off. Then, as the vehicle 1 is advanced further so that the position of the mark 90 coincides with the position of the radioactive substance 2, the output of the G–M tube attains the maximum level and the signal lamp 64 is turned on continuously. On the contrary, as the radioactive substance 2 is moved away from the mark 90, the flashing period is increased and the flashing is eventually terminated. In other words, the vehicle is moved continuously within the pipe P and its position is detected in accordance with such a series of lamp indications.

The signal detected by the detector 61 is supplied via the joint cable 62 to a signal lamp 92 of the indicator 63 installed at the pipe end shop so as to facilitate the control of the vehicle near the operator himself and the signal lamps 64 and 92 are turned on in synchronism with each other. Numeral 65 designates a level indicator for indicating the magnitude of the detection signal, 94 detector sensitivity adjusting knobs, and 95 indicator sensitivity adjusting knobs.

The inside television camera 7 and an illuminating lamp (not shown) are mountable on the vehicle 1 as mentioned previously and this is effected by fastening a television holding jig 8 to the fixed base 5 with jig fastening screws 6′ and fastening the camera 7 to the jig 8 with a camera adjusting screw 9. As shown in the illustration, the screw 9 can adjust the vertical angle of the television camera 7 and it can make a fine adjustment of the television position with respect to the longitudinal direction of the vehicle 1 in association with the elongated hole of the television holding jig 8. It is to be noted that as shown in Fig. 17, the supply of power and the transmission of control signals are respectively effected via the control cable 10 by the generator 73 and a television monitor controller 67 which are installed on the outerside of the pipe and the internal conditions of the pipe are monitored by displaying them on the CRT of the television monitor controller 67.

Next, the automatic grinding-cleaner 110 mounted on the vehicle 1 of Figs. 3 and 4 will be described in greater detail in reference to the Figs. and Fig. 17.

Numerals 13 designates a grinding -cleaning air motor whose rear end is inserted into a supporting tube 15 and fixed in place by fastening screws 16. Also, the supporting tube 15 is designed so that it is fitted into the circular hole of the fixed base 5 and fastened by the screw 38 for supporting and adjusting the height of the radioactive substance 2 so as to facilitate its mounting and demounting. Firmly mounted on the forward end of an air motor shaft 17 with nuts 14 is a disk 11 having a plurality of twisted piano wires 12 fastened to the peripheral portion in a dangling manner.

When air is supplied to the air motor 13 from an air control box 70 through the grinding-cleaning hose 57, the air motor 13 rotates the holding disk 11 at a high speed.

By virtue of this high speed rotation, the twisted piano wires 12 attached danglingly to the peripheral portion of the holding disk 11 are spread outwardly by centrifugal force so that a strong impact force is applied to such harmful substances to coating operation as the welding slag, welding heat burnt-loss coating, rust, etc., remaining on the pipe inner wall and they are cleaned by grinding.

When the air supply from the air control box 70 is stopped, the twisted piano wires 12 complete the grinding-cleaning operation and the twisted piano wires 12 are restored to their initial dangling condition upon stopping of the rotation of the disk 11. thus completely eliminating the danger of the existing coating being damaged by the piano wires 12 during the movement of the vehicle 1 within the pipe.

Also, a cleaner 87 essential for one step of the grinding-cleaning operation is attached by cleaner screws 43 to the vehicle base 40 in the rear lower part of the vehicle 1. In order to discharge to the outside the welding slag, burnt-loss coating, rust, etc., which were broken off to around the below portion of the pipe position $P_1$ by the impact force of the piano wires 12 as mentioned previously, the compressed air supplied from the air control box 70 via the clearing air hose 77 is supplied to an air inlet 96 of the cleaner 87 shown in Figs. 6, 12a and 12b and purged through air blowing ports 97.

The purging direction is opposite to the direction of travel of the vehicle 1, that is, it is directed toward the pipe end through which the vehicle is inserted. The air pressure is directly connected to a compressor 68 without being controlled by a valve, etc., and the cleaning is effected positively only with a loss correponsinging to the amount of hose pressure loss.

Next, a coater 111 will be described in greater detail with reference to Figs. 13 to 17.

A coater proper 49 is fitted into the same circular hole of the fixed base 5 into which the supporting tube 15 is fitted during the previously mentioned grinding-cleaning operation and a gear box 48 and a coating air motor 46 are connected to the front part of the coater proper 49. When the compressed air from the air control box 70 installed outside the pipe is supplied to an air motor hose 47 via a coating air hose 55, the air motor 46 is instantaneously rotated and the number of rotations proportional to the reduction ratio of

the gear box 48 is transmitted to a nozzle holding tube 50 thereby rotating a tip 53, a nozzle 54 and an extension nozzle 52 which spray a coating material to the pipe inner wall within the pipe.

The supply of the coating material to the coater 111 is effected by first supplying the coating material from a hopper 76 to a spray pump 75 in Fig. 17 and then forcing the material pressurized by the pump 75 to the coater proper 49 through a coating material hose 58. When the coating material is introduced, the material is fed through the coater proper 49, the nozzle supporting tube 50 and the extension nozzle 52 forming a coating material passage and sprayed through tip 53 in a fan shape thereby applying the coating to the inner surface of the pipe. The supply and stopping of the coating material is effected through the opening and closing of a needle valve 91 incorporated in the coater proper 49 and the power required for the valve opening and closing purposes is supplied by an air cylinder 93 connected to the air control box 70 through an air hose 55'. It is to be noted that during the coating operation the position of the nozzle holding tube 15 is adjusted by the plate thickness of the fixed base 5 and liners 98 so as to be placed on the diametrical center line of the pipe in the like manner as the position of the grinding cleaning air motor shaft 17.

Also, in order to meet a change in the pipe diameter, adjusting nuts 51 are provided so that any desired coating surface distance and coating pattern width are selected.

Figs. 18a and 18b show the manner in which a T-type extension nozzle 59 and coating tips 60 and 60' particularly adapted for inner surface coating purposes are mounted. While the ordinary inner surface coater is provided with a single nozzle tip and the coating of the inner surface is effected by the rotary motion of the tip while spraying the coating material in a fan shape from the tip as mentioned previously, the use of the single nozzle tip involves such inconveniences that the proper coated surface pattern is not obtained and sometimes the coating material is not sprayed due to the clogging caused by such foreign matter as cured coating pieces, etc., included in the coating material under pressure during the spraying and so on.

In order to overcome these inconveniences, in the case of Figs. 18a and 18b the T-type extention nozzle 59 is attached to the front part of the nozzle holding tube 50 by lock nuts 51' and the opposing coating tips 60 and 60' are arranged on the forward end of the nozzle 59. In addition, the spray direction of the coating material from each nozzle tip has an angle and their spray directions are slightly by a small angle in the opposite directions from the pipe center axis so as to prevent the coating material sprayed from the tips from interferring with each other. As the consequence of this double tip nozzle, the troubles due to the clogging with the coating material are reduced by half and also the amount of spray for coating the whole inner surface at long distances is increased with the resulting reduction in time.

While the constructions of the operating units required for the long-distance inner coating have been described so far with respect to the embodiments, the operating steps performed by these operating units will now be described.

As shown in Fig. 17, the vehicle carrying the grinding-cleaning unit is mounted on a launcher R and ribs 84 welded to the launcher R are attached to a pipe end 85 of a pipe P thereby closely contacting the pipe end 85 and the launcher R.

The auxiliary wire 82 from a wire reel 81 is connected to a hook 23 of the vehicle. The vehicle driving conductor cable 56 has its one end connected to the vehicle control panel 66 connected to a primary cable 79 from the generator 73 and other end connected to the vehicle through a vehicle drum 78. The inside television camera control cable 10 is connected to the vehicle from the television monitor 67 through a television drum 80. The grinding-cleaning air hose 57 has its one end connected to the air control box 70 connected to the compressor 68 by a primary air hose 69 through a drain pipe 71 and other end connected to the vehicle through a grinding-cleaning drum 106. The cleaning air hose 77 is connected to the air control box 70 and the vehicle through the similar paths as the grinding-cleaning air hose 57.

On the other hand, if the inner surface to be cleaned by grinding is limited to a weld position $B_1$, using the mark 90 as a guide, the detector 61 is rested on the pipe P at a position $P_2$ which is short of the position $B_1$ by a distance L and the detector 61 is connected through the joint cable 62 to the indicator 63 located at a site externally of the pipe. When the start button of the vehicle control panel 66 is depressed, the vehicle starts moving. As the vehicle approaches the first weld position $B_1$ from the pipe end, the G–M tube in the detector 61 previously rested on the pipe at the position $P_2$ starts reacting to the radioactive rays from the radioactive substance 2 so that when the radioactive substance 2 and the mark 90 coincides, the signal lamp 64 is turned on continuously and then the vehicle is stopped. These circumstances are all grasped simultaneously on the indicator 63 located at the outside site and it is so designed that the transition from the flashing operation to the continuous lighting operation is judged quantitatively by means of the level indicator 65 and not by the indicator signal lamp 92.

Then, when the compressed air is supplied

to the grinding-cleaning air motor 13 from the air control box 70 so that the air motor 13 is rotated, the holding disk 11 mounted at the motor forward end is rotated and the twisted piano wires 12 remove the welding slag, burnt-loss coating, rust, etc.

Since the next cleaning operation is performed at the next weld position $B_2$ beyond the weld position $B_1$, the detector 61 is rested afresh on the pipe at a position which is short of the position $B_2$ by the distance L and the operation of moving and stopping the vehicle, grinding and cleaning the inner surface by the twisted piano wires 12 and so on is performed in the same manner as mentioned previously. This series of grinding-cleaning operations are repeated successively from the first weld position $B_1$ to the deepest weld position $B_n$. After the grinding-cleaning up to the welding position $B_n$ has been completed, the vehicle is continuously moved backward toward the pipe end 85 and the air is blown continuously from the air blow ports 97 of the cleaner 87. Thus, the welding slag, burnt-loss coating, rust etc., which have already been rubbed off to the pipe lower part are discharged to the outside of the pipe at a stroke while taking up the hoses on the drums.

After all the required grinding-cleaning operation of the inner surface of the pipe has been completed, the vehicle is moved back onto the launcher R. When this occurs, the holding tube 15 of the grinding-cleaning air motor 13 is detached from the fixed base 5 and the cleaning air hoses 57 and 77 are disconnected with the vehicle thus mounting the coating unit on the vehicle. However, the components used concurrently for the grinding-cleaning and coating purposes, i.e., the auxiliary wire 82, the conductor cable 56 and the inside television camera control cable 10 are not removed. Since the coating operating is performed starting at the deepmost weld position $B_n$ in the pipe, the vehicle is moved to the weld position $B_n$ first and it is then stopped. The coating material hose 58 is connected to the vehicle from the spray pump 75 through the coating drum 72 and the compressed air for driving the air cylinder 93 incorporated in the coater proper 49 and the coating air motor 46 which turn on and off the supply of the coating material, is supplied through the single common coating air hose 55 and divided into their associated cylinder air hose 55′ and air motor hose 47 within the vehicle. If the spray pump 75 is operated to fill the coating hose 58 with the pressurized coating material prior to the coating, upon opening the lever of the air control box 70 the rotation of the tips and the spraying of the coating material are effected simultaneously and the coating of the inner surface at the weld position $B_n$ is completed in an instant.

The coating operation is effected by successively repeating the same steps at each of the welds while moving the vehicle from the deepmost weld $B_n$ to the first weld $B_1$ thereby applying the coating to the inner surface at all the welds.

While the standardized embodiment of the invention using the single motored self-propelled vehicle has been described in detail, another embodiment adapted for longer-distance coating is shown in Figs. 7 and 8 which uses a tractor 1′ of the four wheel drive type in which the same electric motor 18′ and transmission gear 19′ as their rear counterparts are mounted in the vehicle forward portion including idle wheels 27 and the idle wheels 27 are changed to drive wheels 25′. Figs. 19a and 19b show the construction of grinding-cleaning and coating units utilizing this drive system.

The tractor 1′ or the two motored self-propelled vehicle and the grinding-cleaning and coating units form completely separate mechanisms. In other words, the units mounted on the vehicle including the grinding-cleaning unit, i.e., the grinding-cleaning air motor holding tube 15, etc., the radioactive substance 2, etc., the inside television camera 7, etc., and the fixed base 5, etc., are mounted on a driven truck 88 including truck rollers 103 and a frame 102. Numeral 99 designates slide plates which are each connected to one of screws 101 of the fixed base 5 and a thumbscrew 100 of each sliding slot plate 104.

When the pipe diameter is changed thus making it necessary to shift the air motor shaft 17 onto the center line of the pipe diameter, the thumbscrews 100 are loosened and slid so as to bring the shaft 17 on the center line.

The connection between the tractor 1′ and the grinding-cleaning unit is effected by a method of fastening together a truck connecting rod 105 extended to the rear of the driven truck 88 and a tractor-side hauling connecting rod 107 by a universal joint 112 thus allowing the tractor 1′ to force the driven truck 88 or the grinding-cleaner into a pipe.

In the like manner as the grinding-cleaning unit, the coater unit is mounted on the driven truck 88 and moved within the pipe by the tractor 1′. The rest including the operations and details are the same as mentioned previously.

hile the position detector unit employing a radio-active substance is applicable for example to the case of a joint-use pipe, aqueduct bridge, shield inside piping and long pipe line utilizing a right of way where the detector 61 can be brought into direct contact with the pipe during the piping work or after the completion of the piping, in the case of a driving pipe and buried pipe line the position detection of welds, etc., is effected by means of the inside television camera since the detector 61 cannot be rested on the pipe outer

surface.

It is to be noted that if it is desired to make possible a longer distance coating under conditions where the radioactive substance unit can be used, the apparatus may be used by removing the inside television camera 7 and its control cable 10 to reduce the burden on the traction of the vehicle or the tractor.

By virtue of the equipment, the distance of travel is increased very greatly and the efficiency of the coating operation is improved.

CLAIMS

1. An inner-surface coating apparatus for pipes which moves an operating unit for grinding-cleaning or coating into a pipe and performs a coating operation on the inner surface of the pipe by remote control, the apparatus comprising:

a self-propelled vehicle movable within a pipe by endless crawler means;

means for detachably mounting said operating unit on a forward end of said vehicle;

a radioactive substance mounted on said vehicle so as to maintain a fixed positional relation therewith for detecting a position of said vehicle within said pipe from the outside thereof;

cleaning means connected to said vehicle for cleaning the interior of said pipe;

driving electric motor means mounted on said vehicle for driving said endless crawler means; and

remote control means for controlling the operation of said operating unit, said cleaning means and said driving motor means externally of said pipe.

2. An apparatus according to claim 1, further comprising a television camera for televising the interior view of said pipe.

3. An apparatus according to claim 1, wherein said operating unit is directly fixedly supported on a front part of said vehicle.

4. An apparatus according to claim 1, wherein said cleaning means is directly fixedly supported on a rear part of said vehicle.

5. An apparatus according to claim 1, wherein said radio-active substance is mounted faceup on said vehicle, and wherein said apparatus further comprises means for adjusting a height position of said radioactive substance.

6. An apparatus according to claim 1, further comprising means for adjusting a height position of said operating unit.

7. An apparatus according to claim 1, wherein said vehicle driving motor means include two electric motors, wherein a driven truck is coupled to the forward end of said vehicle by coupling means, and wherein said operating unit and said radioactive substance are mounted on said driven truck.

8. An inner-surface coating apparatus for pipes, substantially as hereinbefore described with reference to, and as illustrated in, Figs. 3 to 19 of the accompanying drawings.

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